trious, that few names in the registers of Time will excite more curiosity than that of William Pitt." — *Memoirs*, Vol. II., pp. 385 - 388.

ART. VI. — 1. *An Account of the Trigonometrical Survey of Massachusetts.* By SIMEON BORDEN, Esq. Published in the Transactions of the American Philosophical Society of Philadelphia. Vol. IX. Part I. 4to.

2. *A Topographical Map of Massachusetts, founded on Trigonometrical, Astronomical, and Local Surveys, made by Order of the Legislature.* SIMEON BORDEN, Superintendent. Published by the State. Boston. 1844.

THE triangulation and survey of Massachusetts for the purpose of constructing a map of the State, and the publication of the map itself, are matters, which, for various reasons, are worthy of some consideration in our pages. The excellent example which has thus been set, we hope, will soon be followed by some of the sister States, and the experience gained in executing this survey, the first of the kind on a large scale which has been made in this country, may be of use in directing their operations. Mr. Borden's modest account of his highly meritorious labors, and of the many ingenious methods which he contrived in order to insure accuracy in his work, is interesting throughout ; but we shall confine our notice chiefly to his details of the history of the survey, and to some of the methods used and the results obtained. The character of the map, and some facts connected with it and its publication, will also be noticed.

The history of the survey, Mr. Borden states, commenced in March, 1830, when the legislature of Massachusetts passed resolves requiring the city of Boston and the several towns in the Commonwealth to make an accurate map, each of its own territory, upon a scale of one hundred rods to an inch, and to deposit the same in the office of the Secretary of State. These resolves gave directions in detail respecting the subject. During the same month, a resolve was passed, authorizing the governor to appoint skilful survey-

ors to make a survey of the State upon trigonometrical principles, combining astronomical observations with their work. Some time in the following summer, the governor appointed an astronomical and a topographical surveyor. During the season, most of the instruments were procured, and Mr. Borden was called upon to make an apparatus for measuring the base line. In the autumn, a location for the base line was selected, and the line was partially traced. This was all that was done in 1830. In the course of the ensuing winter, Mr. Borden made the measuring apparatus, and repaired the instruments. The apparatus being ready early in the spring of 1831, astronomical and chronometrical observations were commenced by the astronomical, and the surveys and triangulations by the topographical, surveyor. Mr. Borden was at this time assistant to the latter, and continued to be so for three years ; at the termination of that period, the topographical surveyor resigned, and the governor placed the survey under the charge of Mr. Borden.

In 1838, the astronomical surveyor made his final report, and the responsibility of completing the work devolved on Mr. Borden. At this time, the field work was supposed to be completed, and the necessary trigonometrical computations for compiling the map were commenced, when a difficulty was discovered, that might have been expected, considering the great number of individuals who had been employed on the various surveys. This difficulty was caused by the action of the legislature, who wished to save political reputation by saving the funds of the State treasury at the expense of the town treasuries, the expenditures from which would not be so publicly noted. The account before us thus describes the evil.

" After I had completed the field work, and had calculated a sufficient number of the main triangles to cover a section of fifty miles square of the western portion of the State, I commenced the work of compiling the map, when I found that the town maps had been returned to the Secretary so incorrectly drawn as to render it impossible in their actual state to make a satisfactory map from them. I was then obliged to go into the field again, with four or five assistants, to make corrections ; and this operation has been one of continual perplexity, and has cost the State, in my department alone, at the least estimation, ten thousand dollars more than it would have done had the towns

executed their portion of the work in good faith. It is my opinion, that, had the work been performed from beginning to end under the direction of a faithful and competent engineer, it might have been executed, at the rate of compensation which has been paid, for many thousand dollars less than it has now cost.

"Still, the survey of the State of Massachusetts, including eight thousand two hundred and thirty square miles of territory, and having an indented sea-coast of about three hundred miles, has been completed in a little more than ten years, at an expense of only sixty-one thousand three hundred and twenty-two dollars." — p. 34.

To this expenditure must be added about nine thousand five hundred dollars, paid chiefly for engraving and printing about eight hundred copies of the map for distribution among the several towns of the Commonwealth, the members of the legislature of 1844, the State's members of Congress, the president and vice-president, and the several departments at Washington. The whole cost to the State was nearly seventy-one thousand dollars. The act for the publication of the map provided, that the publisher, in return for the sum received by him from the State, and for the copyright of the work, should be obliged, for the term of three years, to furnish copies of the map to any applicant at the price of five dollars each, or about one half the amount for which any private individual could afford to get up such a work.

After the history of the survey, Mr. Borden enters into some details respecting the instruments and methods used, and then describes very fully the results obtained from his arduous and skilful labors with them. The first work was measuring the base line for the system of triangulation throughout the State, — a work entitling him to the greatest credit. The apparatus by which the base line was measured was of his own invention and construction, and so accurate did it prove, that two separate and independent measurements of a line over seven miles in length differed only 0.237 of an inch, a result showing a degree of perfection in the instruments and their use which we think has never been surpassed. A correct base line is so important an element of a trigonometrical survey, that we deem it of sufficient interest to transcribe from Mr. Borden's second

paper as perfect a description of the instruments used as can be made intelligible without reference to his diagrams; and we give the account more in detail, because it has not yet been published.

The standard of length first selected was a scale two feet in length, constructed upon compensation principles, and of course unsuitable for division. When afterwards compared at Washington, by Mr. Hassler, of the United States coast survey, with his eighty-two-inch scale of Troughton's construction, which is an exact copy from the well known Troughton scale of Sir George Shuckburg, it was found, at the temperature 57° Fahrenheit, to be 0.0018 inches too short. The Massachusetts scale was used to complete the calculations with, and the corrections were made after a proper standard was fixed upon, which was Hassler's eighty-two-inch Troughton, at 62° Fahrenheit.

The apparatus with which the line was measured is fifty feet in length, and is contained within a strong and firmly soldered tin tube, eight and one-fourth inches in diameter, by which it is supported. It consists of two rods, three eighths of an inch in diameter, one of steel, the other of brass. These rods project six inches at both ends of the tube. They are each in four pieces, of nearly equal lengths, and are united, as it were, into two continuous rods, by what machinists call coupling-boxes. These are cylindrical in shape, about three inches long, and seven-eighths of an inch in diameter, with a hole passing through their centres longitudinally, of the size of the rods. A hole also passes transversely through the middle of the coupling cylinder, through which the observer may see that the ends of the rods are free from dirt or extraneous matter. The end of one of the rods having been inserted into the coupling-box until it makes its appearance in the centre of the transverse orifice, a hole of proper size is drilled through the box and the centre of the rod, in which a pin is inserted, and its ends riveted, so as firmly to bind the rod and coupling-box together. The end of the next rod is provided with a thin mortise, of a size proper to receive a suitable key; the coupling-box, also, has a mortise to correspond to that in the rod. The mortised end of this rod is then inserted into the box, until it comes in contact with the end of the rod to which the coupling-box has already been secured. Then,

by examining the ends as seen in the transverse orifice, they may be made to meet each other properly. The key is then driven into the mortise, and keeps the ends of the rods firmly in contact with each other. The couplings belonging to the steel rods, as well as the pins and keys, are made of steel ; those belonging to the brass rod are made of brass. These rods are supported within the tube by nineteen supports of cast-iron, each held in its place by five screws, to keep them in a single plane, and the rods straight when in their place.

Near the centre of each sheet of tin of which the tube is composed is soldered a ring or flange of tin, one inch deep, which serves to stiffen the tube and prevent it from collapsing while in use ; the nineteen supports are placed near these flanges. The tube is about forty-nine feet long, made in four pieces of nearly equal length ; they are attached to each other by small screw bolts passing through strong brass flanges, which are soldered into the ends of the several parts. These flanges are cast of sufficient length and strength to serve as bearings, to rest in the Y's of the trestles and support the tube. Each end of the tube, considering all the pieces as one, is tapered to about the size of the inside of the flanges placed within it, and has a cast-iron end fitted to it. Through these iron terminations the brass and steel rods project, and are attached to couplings similar in construction and principle to those which have been described. These couplings are fastened by movable joints to arms or indices ; and at one end of the measure the index is made to stand at a constant angle with the axis of the tube by a stirrup-like apparatus screwed to this index and the iron end of the tube.

The arrangements at the other end are quite different, though the projection of the rods beyond the tube and their attachment by coupling-boxes to the index are the same. Within the end of the tube is placed a stiff spiral spring, capable of exerting an expansive force equal to several hundred pounds. There are two circular pieces of cast-iron, with flanges projecting in such a manner as to retain the spiral spring between them ; and another piece of circular iron closes the end of the tube. The inner plate of iron is held in its position by two screws, which pass through the iron end of the tube, through a loop or projection of the centre plate, and through this inner plate, and is secured by screws

and nuts. An iron rod of three fourths of an inch in diameter passes through the centre of the plates and spring to the arm or index. The two screws which hold the inner plate force the spiral spring against the centre plate, which centre plate comes in contact with a nut that is screwed upon the centre rod, and forces the end of it with all the power of the spring against a steel knife-edge fixed to the arm or index, to which the brass and steel rods are attached at equal distances from it, and thus operates to keep them extended or straightened. An iron frame is arranged outside of the end plate, to protect the portions of the rods which project beyond the tube, and to keep the index steady, or always in the same position with regard to the rest of the apparatus.

Near the end of each arm or index is attached a circular piece of silver, crossed at the centre by two fine lines, at right angles with each other, the intersection of which marks the terminus of the measure. One of these pieces is soldered to the arm, the other is soldered upon the head of a screw bolt or clamp, that it may be adjusted so as to make the measuring apparatus of the desired length. The proportions are so regulated, that the distances on the indices from the termini to the rivets which secure the steel rod are to the expansion or contraction of steel, as the distances from the termini to the rivets which secure the brass rod are to the expansion or contraction of brass. If these proportions have been accurately determined, and the terminus marked upon one arm be attached to some stationary object, and a microscope placed securely over the other terminus, it will be evident, from a careful consideration of the arrangement of the apparatus, that the brass and steel rods may expand and contract to the full amount that the differences of temperature require, without changing the position of the terminus under the microscope.

The tube or measure is supported upon two tripods or trestles, very carefully and substantially made, the legs being in two parts, and provided with screws and bolts to lengthen or shorten them as required, and to tighten the joints in case of their shrinking or becoming loose from wear. The Y upon which the tube rests is fixed on a sliding frame levelled with the ordinary levelling-screws, and moved and screwed horizontally with thumb-screws. The microscopes for each end of the measure are compound ones, consisting of a sin-

gle object lens, and a compound eye-piece of two lenses, with cross hairs at the common focus. The focal distance is about one and five eighths of an inch. They are placed upon trestles, in principle and construction similar to those for the tube, the dimensions being something less. To the sliding frame of the microscope-stand are attached columns to support the microscope, instead of the Y upon which the tube rests.

After describing the instruments employed in measuring his base line, Mr. Borden enters fully into the manner of using them. The base line chosen was on the Connecticut river, above Northampton, and was found to be 39,009.73 feet, or 7.3882 miles, long. Each terminus of the line was marked by a cross on the end of a copper bolt fixed in a large stone firmly bedded in the earth, and extending about eighteen inches beneath the surface. Before measuring the line, it was very accurately run and marked with a theodolite, and afterwards a theodolite was used for each placing of the measure. Eight men were employed in measuring the line, and the manifold operations, performed with great care in the measurement, are very minutely described, and seem well calculated to insure very favorable results.

Mr. Borden next enters into some particulars respecting the operations connected with the triangulation. A twelve-inch repeating theodolite, made by Troughton, with a vertical circle attached, was used to measure the vertical angles, and a telescope forty-six inches in focal length, made by Mr. Borden, to measure the azimuth angles. The various signal-staffs and stations are fully described, and good judgment appears to have been shown in making and using them. The superintendent mentions several atmospheric phenomena, which came under his observation in the course of the survey, some of which he explains in a very satisfactory manner. We quote one passage respecting the transparency of the atmosphere.

"As respects the transparency of the atmosphere, I have made many observations with the view of ascertaining the reasons why distant objects cannot be distinctly seen on certain days when the atmosphere appears to be uncommonly transparent.

"At the latter end of November, 1835, I was at the station in Fairhaven. Soon after our arrival, we had a fall of several

inches of snow; severe cold weather succeeded it; and, although the atmosphere appeared uncommonly transparent to the unassisted eye, still we were unable to see our distant signals. In a few days after the snow had fallen, the weather became warmer, and a rain ensued which took off nearly all the snow; on the morning following the rain, the 5th of December, we went early to the station, and discovered that all of our signals could be seen with tolerable distinctness, although the atmosphere was apparently not near so transparent as it had been at several of our previous visits to the station. The heavens were densely clouded. I think the sun did not appear at all, or if seen, it must have been so very dimly as not to have perceptible influence on the atmosphere. The day, of course, was, comparatively speaking, a dark one. We commenced our operations of measuring angles as rapidly as we could; but we had not been long engaged in our work before the atmosphere began to present a very curdled appearance, and our signals to appear dim; in a short time they appeared plainer again, and then again more dim; the appearances thus alternating. Having a thermometer, I directed one of my assistants to see if any changes took place in it corresponding with the changes in the appearance of the signals; and we soon ascertained that these changes always occurred together. A slight change of the instrument could be easily detected from the appearance of the signals, particularly when looking across water. I think the change of appearance was not so strikingly apparent across land." — pp. 40, 41.

After making these observations, Mr. Borden gives his estimates of the temperature of the surface of the land and water across which the observations were made. He then says: —

"I came, therefore, to the conclusion, that the nearer the atmosphere and the surface of the earth or water across which the line of sight lies are to the same temperature, the more distinctly can distant objects be seen in an atmosphere of equal transparency." — p. 42.

And further to elucidate the subject, he describes the different appearances of distant objects.

"I would premise, that the atmosphere is supposed to be transparent, that is, free from fogs, smoke, dust, or other heterogeneous matter. We commence in the morning. Our reason will teach us, that the surface of the earth and the atmosphere are oftener at the same temperature at this time. Objects in the morning appear perfectly still, and present a well-defined

outline. As the sun rises, the surface of the earth absorbs warmth more readily than the air, and, of course, the stratum of air which lies in immediate contact with the earth becomes rarefied and rises, forming ascending currents, while the vacuum is supplied by descending currents. In consequence of this condition of the atmosphere, distant objects present a waving appearance; the light reflected from them appears to be sluggishly refracted from right to left, and from left to right, — the image of the objects appearing of about the same dimensions as when first observed, and with still a distinct outline. The sun continues to rise; the heat increases, and with it ascending and descending currents in the atmosphere; the images of the objects lose their wavy appearance, and appear larger and fainter; the refractions from right to left and from left to right succeed each other with such rapidity that all further appearance of distinct outline disappears, and, in proportion as their apparent size increases, their distinctness diminishes, until, if the objects be small and far off, no traces of them can be seen.

"If we suppose a diminution of heat, from the temperature of distinct sight, in the same ratio that we have been supposing an increase (which frequently takes place in the afternoon of a cold day), objects will present similar appearances, and vanish in the same manner." — pp. 42, 43.

Mr. Borden explains minutely his process of determining the azimuths of the stations, and the system adopted of preparing them for the map. In the account of the vertical triangles and levelling of the primitive stations of the survey, the level above mean tide of many of the most prominent stations throughout the State are put down. We give the level of a few of the stations.

"Cupola of State House,	Boston,	248.84 feet.
Nahant,		89.90 "
Blue Hill,	Milton,	635.05 "
Prospect Hill,	Waltham,	482 27 "
Manomet Hill,	Plymouth,	394.25 "
Cassicut Hill,	Fall River,	355.00 "
Holt's Hill,	Andover,	422.95 "
Wachusett Mountain,	Princeton,	2022.02 "
Mount Tom,	Northampton,	1213.63 "
Watatic Mount,	Ashburnham,	1847.35 "
Bald Peak,	Mount Washington,	2623.65 "
Saddle Mountain,	Adams,	3505.50 "

"The mean refractions were found to vary from one tenth to one twentieth of the arc upon the earth's surface contained be-

tween two stations. In the western portion of the State, the refractions appeared to be much more regular than they were in the eastern, rarely exceeding one twelfth, or falling short of one sixteenth, of the contained arc. This phenomena is probably owing to the trigonometrical stations being much more elevated above the country which surrounds them in the western portion of the State than in the eastern." — pp. 46 - 48.

The latitude and longitude of many places throughout the State were obtained. The remainder of the account, which is the larger portion of it, is occupied with the astronomical and the topographical surveyors' statements of their labors connected with the survey, and a comparison of the results of Mr. Borden's triangulation with those obtained from the astronomical observations. These comparisons afford additional proof of the correctness of the results obtained. We may say here, that several of the trignometrical lines have been verified by the United States coast survey. The line between Pocasset Hill, Tiverton, and Quaker Hill, Portsmouth, R. I., from six to seven miles in length, as determined by the two independent surveys, differed but $\frac{22}{100}$ths of a foot. There is attached to the account an engraved plan of the principal triangles in the survey.

The whole map, as published, is seven feet in length, by four and a half feet in breadth, and is beautifully executed. It contains, first, a map of the State on a scale of two and one half miles to the inch, showing the town boundaries, roads, rivers, mountains, and the topography of the country generally, and the elevation of the different stations of the triangulation; secondly, a geological map or plan, taken from Professor Hitchcock's geological survey, on a scale of five miles to the inch; thirdly, a table of the latitude and longitude of all the light-houses, and a number of other important points in the State; and fourthly, a table giving the year of incorporation of the different counties, towns, and districts, and the population by each census taken by the United States.

It is to be regretted, that, instead of this last table, the contents of which are to be found so readily elsewhere, the space it occupies was not filled with the plan and some of the details of the principal triangles of the survey, on a scale of ten miles to the inch. This would have added much to the scientific character and usefulness of the map,

and rendered it more worthy of circulation abroad as well as at home. It is a work highly honorable to the State, and should be circulated not only for the information which it will convey, but as an example for the sister States of the Union to follow.

We hope there will be liberality enough in the next legislature to publish a new edition of the map, with the alteration suggested, and to order its distribution to the different colleges and literary institutions of the country; and especially, for the honor of the State, that a number of copies may be presented to Mr. Borden, not by way of remuneration, but as testimonials of respect, and of satisfaction with the manner in which he has discharged his duty. Thus far, he has received only the single copy to which he was entitled as a member of the legislature. Professor Hitchcock received twenty copies of his report, and other persons have been thus remembered in the distribution of the State reports. Why this exception with regard to Mr. Borden? We think it is because the members of the legislature were not aware how much the Commonwealth is indebted to him for the beautiful specimen of art of which they see only the result; the means by which that result was obtained they do not see or know. If they will examine the heterogeneous mass of materials from which the map is compiled, if they will look over that pile of most remarkable documents in the Secretary of State's office, called the "town plans," they will be in some degree enlightened as to the quantity of labor and skill which Mr. Borden has brought to bear upon the work. Each of these plans contained more or less of error; he had to bring them together in such a manner, that the sum of the errors should be a minimum.

This object was attained by a new and most ingenious application of the instrument known in optics as the *Camera Lucida* to the purposes of topographical drawing, by which single invention Mr. Borden not only eliminated the greatest possible amount of error, but also made a great saving in time. This instrument, made in Boston on Mr. Borden's plan, has been introduced into the office of the United States coast survey, and into the bureau of the topographical engineers; and we learn that an experienced draughtsman, who has examined it, has stated that five thousand dollars *per*

annum would be saved in time in these offices by its use. This is but one of the many ingenious methods contrived by Mr. Borden for insuring accuracy and saving expense ; the whole history of the survey of Massachusetts is full of them. We learn, too, that the base-line apparatus invented and made by him is to be introduced in the coast survey, as well as his signal-staffs ; and that the instruments made by him for use both in the field and the office are all much superior in character to those found elsewhere. In fact, to whatever department of trigonometrical surveying Mr. Borden turned his attention, he always made improvements upon old methods ; and whatever rank the survey of Massachusetts, considered as a scientific work, now holds, or is destined to hold, and whatever accuracy or beauty of execution belongs to the map, the credit of it is justly due to him. It should also be known, that the last appropriation for compiling the map was made on condition that it should suffice for completing the work, — in fact, that it should be the last, — some impatience having arisen from circumstances and delays over which he had no control and for which he was in no way liable. With a due feeling of pride in the proper completion of the map, Mr. Borden continued his labors some six months beyond the time when he could be really held to perform them. We have been somewhat particular in the enumeration of his services, from the fullest conviction that they merit the gratitude of his employers and the respect of the scientific world.

The errors committed by the State consisted, first, in ordering the town plans to be made before the trigonometrical survey was begun, thus losing a correcting influence which would have contributed much to their accuracy ; and, secondly, in ordering these plans to be made by the towns, thus requiring the employment of surveyors of all descriptions, faithful and unfaithful, and in many cases unacquainted with sketching and topography. All responsibility as to correctness was thus left with the officers of these towns, some of whom gave this excuse among others for an incorrect plan, that they presumed the plans of many other towns would be equally incorrect. Another error was committed in not permitting the map to be finished with the topography of the hills, valleys, woodlands, villages, &c., fully represented upon it, at an additional expense of only three or four thousand dol-

lars ; the addition would have made the map of great value to the county commissioners, and saved to each of the western counties a sum much larger than the extra expense. A fourth mistake consisted in not appointing, at the commencement of the work, a competent person, willing to execute it faithfully, and possessing so much of the confidence of the executive and the legislature as to have had the whole work placed under his superintendence, with an assurance that it was to be completed in a manner creditable not only to the State, but to the age. By such an arrangement, the expenses would hardly have been at all increased. These errors, as we believe, are mainly to be attributed to a blind contest for political power, which prevented a liberal and certain appropriation of funds being made for the work, not only at its commencement, but during its execution. Indeed, on two or three occasions, the legislature gave strong indications of a determination to withhold any farther appropriation, and thus to put a stop to the work altogether. On one of these occasions, when consulted by the executive as to the manner in which the survey had been carried on, the writer of these remarks had great satisfaction in being able to say, that he believed it was proceeding in a manner highly honorable to the State. At other times, it was necessary for the governor and other gentlemen interested in the work to exercise all their influence in order to prevent the credit of the State being injured by the abandonment of the survey when already half completed.

With all the troubles and difficulties which had to be encountered in the prosecution of the work, and although a faultless map has not been produced, in consequence of the errors of the town plans, yet, as every part of Mr. Borden's work has been thoroughly and accurately executed, we think it may be pronounced far superior to any map of a considerable portion of territory ever made in North America ; and, notwithstanding many unfavorable circumstances which tended to swell the expense, we believe that no survey of the like extent has ever been made for so small a sum.

We are pleased to see, that the legislature has ordered to be printed and distributed to the different towns and clerks of courts the positions and details of the stations throughout the State, as determined by the trigonometrical survey, accompanied by such other matter obtained in exe-

cuting the work as may be useful in laying out roads, and in the measurement of towns. The preparation of this work, requiring considerable labor and judgment, devolves upon Dr. Palfrey, the Secretary of State.

ART. VII. — 1. *Contributions to the Edinburgh Review.* By FRANCIS JEFFREY, now one of the Judges of the Court of Sessions in Scotland. London: Longman & Co. 4 vols. 8vo.

2. Wiley & Putnam's *Library of Choice Reading: Characters of Shakspeare.* By WILLIAM HAZLITT. New York. 16mo.

3. *Imagination and Fancy.* By LEIGH HUNT. New York: Wiley & Putnam. 16mo.

THE British Reviews and reviewers of the early part of the present century are closely connected with the history of English literature, not only on account of the influence they exerted on public opinion, but for the valuable contributions which a few of them made to literature itself. Some of the most masterly disquisitions in the whole range of English letters have appeared in the three leading periodicals of the time, — the "Edinburgh Review," the "Quarterly Review," and "Blackwood's Magazine." Almost all systems of philosophy, theology, politics, and criticism have been vehemently discussed in their pages. They have been the organs through which many of the subtlest and strongest intellects have communicated with their age. In generalization, in classifying historical events under ideas and principles, in tracing out the laws which give pertinence to seemingly confused facts, in presenting intellectual and historical epochs in condensed pictures, they have been especially successful. But although containing papers of the greatest merit, their general tone has been too much that of the partisan. Being political as well as literary journals, their judgments of authors have often been determined by considerations independent of literary merit. In criticism, they have repeatedly violated the plainest principles of taste,